

MEDUSA for MUNIN and ASTRID-2 Satellite

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LONG TERM GOAL

The long term goal of this grant is to develop a low mass, power, and volume electron and ion electrostatic analyzer for measuring plasmas from a few eV to 10s of KeV energies. A parallel goal is to develop techniques that also lower the overall cost of building flight qualified units. The ultimate science long-term goal supported by this technology is the multipoint (in space-time) measurement capability of low earth plasmas for input to space weather modeling.

SCIENTIFIC OBJECTIVES

Currently, heavy interest is being placed on nowcasting and forecasting of space weather. Auroral plasma energy deposition, along with Joule dissipation, represents the majority of external, non solar photonic energy input into the earths ionosphere, thermosphere, and mesosphere. As such it is absolutely essential to have an accurate, global, space/time resolved determination of this energy source. To date this has not occurred with sufficient accuracy to be effectively used in now- and -fore-casting of spaceweather and its consequences. The chief reason is the high cost of instruments and missions which make it prohibitive to provide a dense enough observations matrix. A new approach is detailed in the next section to allow achievement of these space weather science goals.

APPROACH

In order to measure electrons and ions from eVs to 10s of KeV energies one has to use at least 2 analyzers if not more, to get a complete phase space measurement. We have developed a combined electron and ion tophat analyzer (see Figure 1) that not only decreases the number but eases mounting and FOV problems, plus significantly lowers the mass and volume. This system is referred to as the Miniaturized Electrostatic Dual-tophat Spherical Analyzer (MEDUSA). Both tophat analyzers share a common collimation system and mirror image tophat (see Figure 2). We designed the tophats to have the smallest possible radii consistent with the desired sensitivity. This helps to reduce volume and mass plus it allows us to use off-the-shelf Micro Channel Plates (MCPs) which lowers the cost.

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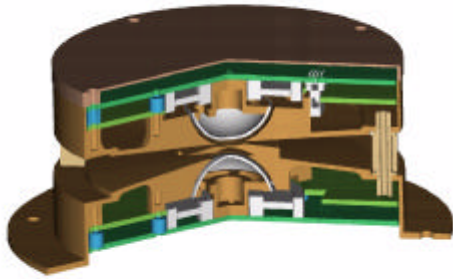


Figure 1

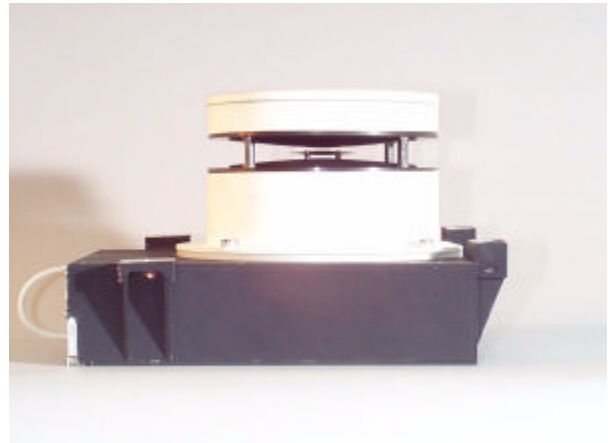


Figure 2

In order to further reduce complexity and mass, the mounting support for the inner plate is part of a single board (Figure 3) which contains the MCP, amplifiers and associated resistance, capacitors, etc. The ion and electron sides each have 16 discrete anodes. A novel, charge sensitive, commercial multi-amplifier is employed. Each part has 8 amps thus requiring only 2 parts per side. The parts are ~\$30 which represents a 100x decrease in cost compared to past implementation. In addition, the reduction in parts count greatly simplifies board layout. The MCP high voltage bias and deflection supply is contained on a single board (per side) (See Figure 4), thus only 2 boards are required to implement the analyzer section.

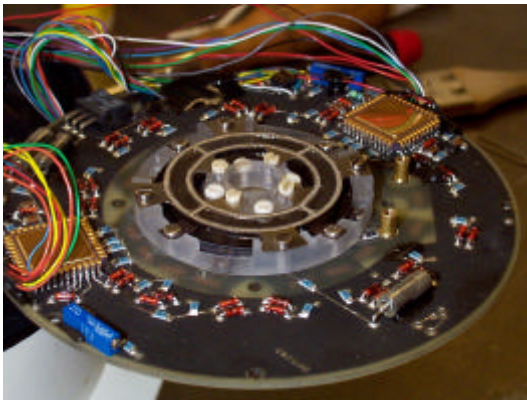


Figure 3



Figure 4

The digital electronics are contained in a small rectangular box (see Figure 2). The analyzer mates through micro-miniature connectors to the electronics box. The complete system has a mass of only 1.7kg and uses a little less than 3 watts.

This system will be flown on the Swedish ASTRID-2 microsatellite (~35 kg and the size of a view-graph machine) in December 1998, thus completing the validation of our low mass, low cost plasma analyzer system.

Based on the success of the MEDUSA effort on ASTRID-2 we were invited to participate in the Swedish MUNIN (<http://munin.irf.se>) nanosat project. The satellite has a mass of ~6 kg, power ~6w, and a volume of 20 x 20 x 24 cm. The ASTRID-2 MEDUSA engineering unit will be refurbished for MEDUSA.

The spacecraft is literally built around MEDUSA (see Figure 5). The actual MEDUSA unit is the white can in the center. A space is used in this photo to hold the top of the engineering spacecraft in place. In the flight MUNIN the MEDUSA will be present. The battery pack is at the bottom right. Left of the battery pack are the transmitter/receiver and central electronics. No separate instrument electronics are used. It is all one big integrated system. In addition to MEDUSA MUNIN will have a near infrared imager and a neutral atom imager. MUNIN is magnetically stabilized along the earth's magnetic field resulting in complete angular distributions.

MUNIN will truly usher in a new era of space platforms. Their low cost and size will allow "flotillas" of spacecraft. Information obtained with MUNIN should establish clear baselines for such future missions.

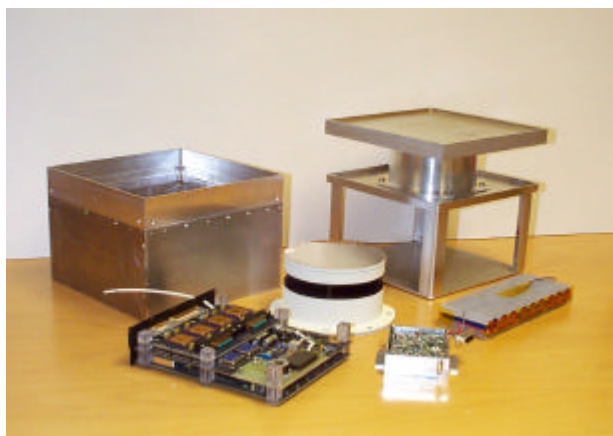


Figure 5

WORK COMPLETED

We will briefly review the last year's progress here. Last years effort included:

1. Support the MEDUSA integration into the ASTRID-2 spacecraft.
2. Support the complete assembly bench checkout of MUNIN MEDUSA.
3. Support the instrument science calibration for both MEDUSA's.
4. Generate software to place the data in Instrument Data File Set format.
5. Aid Sweden in setting up a near real-time data production system.

Each item will be discussed relative to the numbers above.

1. The flight MEDUSA was successfully mated with the Swedish flight spacecraft in late July. No problems were found and the complete end to end testing took less than one day.

2. Bench checkout of the MUNIN MEDUSA was also carried out last summer. A bad amplifier was found and replaced as was a broken MCP. This unit is now undergoing science calibration. It will be mated into MUNIN next year.
3. ASTRID-2 MEDUSA science calibration was completed this summer. It was discovered that the inner hemispheres were made to the wrong radii. We thus had to shim them out to produce the desired characteristics. We could not fully recover the design parameters but came close. This has been corrected for the MUNIN MEDUSA. Figure 6 and 7 show ion and electron calibration data. We will rerun the ASTRID parameters in the computer model for comparison to lab results.
4. The production software for O/A, and MEDUSA has been completed and tested with validation data. PIA is ~75% complete and will be completed next year prior to launch. Final test will occur after launch.
5. We have liased with the Swedes relative to incorporating our software into the realtime production stream. This work is ~50% complete and will be completed by launch.

RESULTS

The MEDUSA instrument is yet to fly so the results are of an engineering nature. The main result is the successful development of a miniaturized, low cost dual-species electrostatic analyzer for auroral plasma measurements. We have developed techniques which will allow us to mass manufacture such systems at a fraction of the typical cost of big NASA style missions. The emphasis has been on quality without unnecessary and unproductive red tape activities. This opens up the possibility for “fleets of measurement platforms” when joined with other related work in nano and microsatellite spacecraft.

Next year we will have launched and be producing scientific data in near-realtime on the web for general usage.

IMPACT/APPLICATION

This instrument technology has now been incorporated into the next generation of ultra-small (6 kg, shoebox size) nanosatellite missions. MUNIN will be launched in October 1999 as a NASA piggyback. This represents the advent of “bouy style”, throw it overboard measurement platforms. It’s cost point will allow a dense web of space/time measurements to be made as part of data input into space weather now and forecasting models.

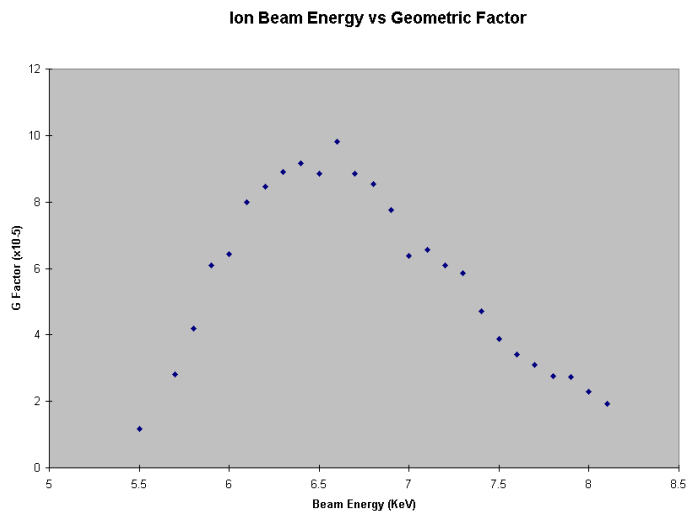


Figure 6

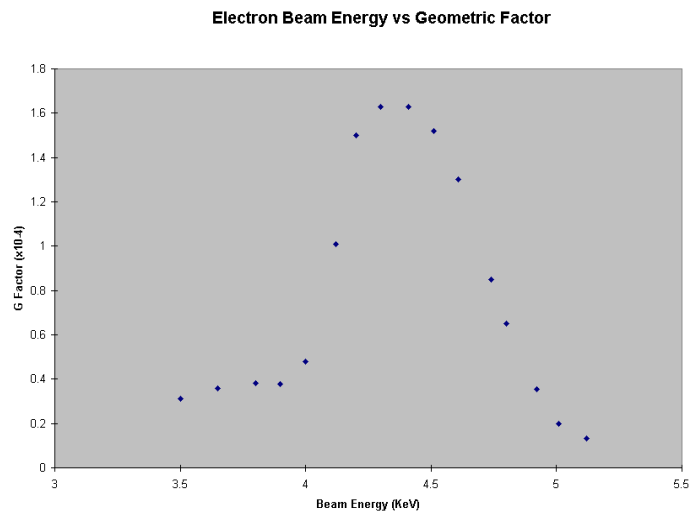


Figure 7

TRANSITIONS

Next year our activities will shift primarily to data analysis and paper production. Part of our work will go to support the MUNIN integration and launch.

RELATED PROJECTS

Based on these efforts we proposed a MEDUSA for the ESA MARS Express Mission. We were successful in our efforts so MEDUSA will now go on to MARS aeronomy. The ONR support has thus produced a large positive result.

URLs

<http://munin.irf.se>

<http://www.ssc.se/ssd/msat/astrid2.html>

<http://mars.irf.se/Astrid-2>

<http://sapin.irfu.se/IRF-U/sat/astrid2>

www.irf.se/~jonas/a2